

THE
CHARACTER AND EXTENT
OF
AIR POLLUTION IN LEEDS.

(A Lecture delivered before the Leeds Philosophical Society,
on March 3rd, 1896.)

BY
JULIUS B. COHEN, Ph.D.,
Lecturer on Chemistry at the Yorkshire College, Leeds;
Lecturer in the Victoria University.

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GOODALL AND SUDDICK, PRINTERS, COOKRIDGE STREET.
1896.

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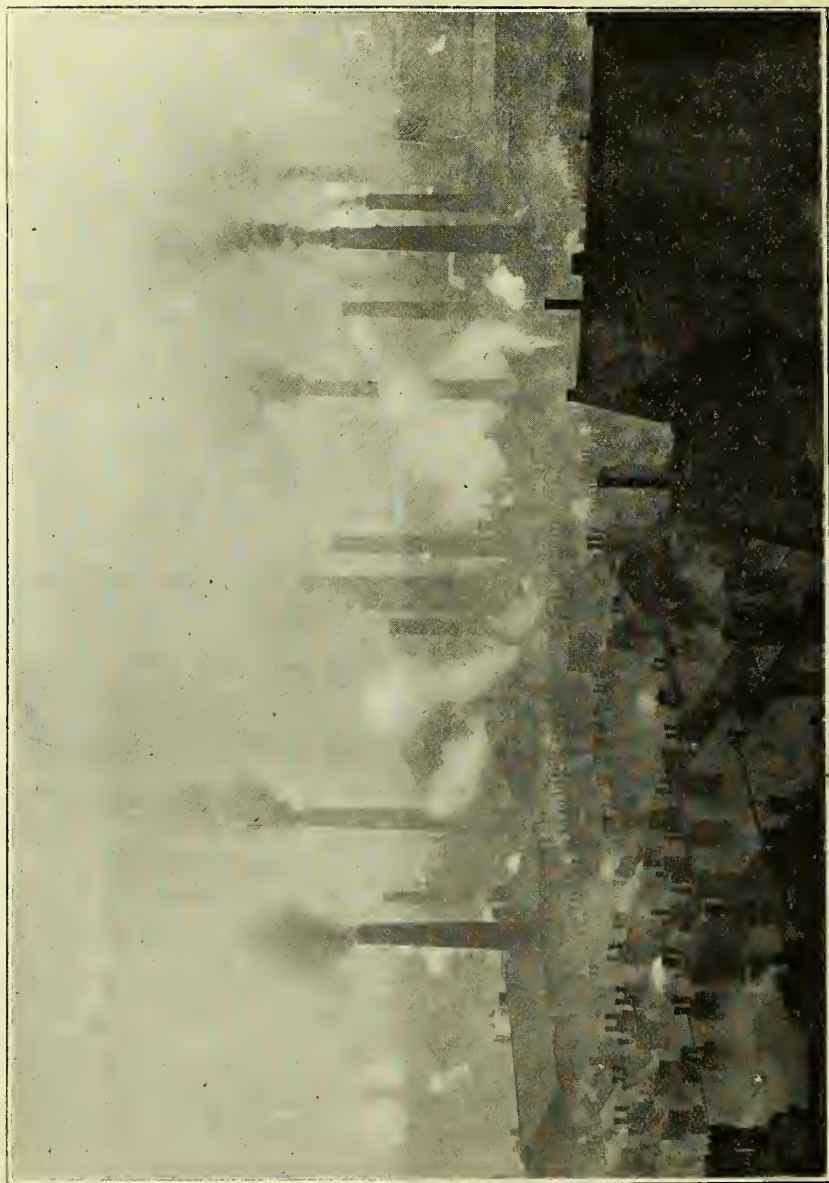
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PHOTOGRAPH OF LEEDS. OVERLOOKING KIRKSTALL ROAD.

THE CHARACTER AND EXTENT OF AIR POLLUTION IN LEEDS.

A LECTURE DELIVERED BEFORE THE LEEDS PHILOSOPHICAL SOCIETY,
ON MARCH 3RD, 1896.

The world is too much with us ; late and soon,
Getting and spending, we lay waste our powers ;
Little we see in Nature that is ours ;
We have given our hearts away, a sordid boon !

Wordsworth.

INTRODUCTION.

WHEN I mention the fact that the solid matter in Leeds air is, on the average, 1·2 milligrammes in 100 cubic feet, I cannot expect that it will convey a very definite idea. Milligrammes are quantities with which most of us are not in the habit of dealing, and even 100 cubic feet is a volume which cannot be realized in a moment. The effect that such a statement will convey therefore depends largely upon the manner in which it is delivered. Thus “the solid matter in the highly polluted air of Leeds amounts to no less than 1·2 milligrammes in 100 cubic feet,” will convey an impression essentially different from that produced by the statement, “The minute amount of solid matter in the air of Leeds, one of the most salubrious of Yorkshire towns, may be judged from the fact that it does not exceed 1·2 milligrammes in 100 cubic feet.” Perhaps this illustration may serve to explain my reluctance in placing before you results of experiments, which demonstrate little more than we already know, viz. : that Leeds is very smoky, and that it would be highly satisfactory if it were otherwise. But I

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felt at the same time that the subject of air pollution in manufacturing towns really deserved more attention than it has generally received ; for the evil is a growing one, and I believe we shall realize one day, as the result of a very costly experience, the same necessity for breathing an untainted atmosphere as we now do for drinking unpolluted drinking water, or for consuming unadulterated food.

Past experience, however, gives us little hope of any immediate remedy in the matter of atmospheric purification. And I lay this mainly at the door of our ungenial climate. If the weather permitted the restless activity of our busy manufacturing centres to relax a little during the day by an hour spent idly out of doors ; if we could sit after the fashion of the Continentals, and drink coffee and smoke under the trees outside club or restaurant, we should begin to feel dissatisfaction with some of the hideous surroundings which we now tolerate, and from which those who can, hasten to escape. But the gloom of winter, followed by the severity of our summer weather, drives us, when work and physical exercise are over, within doors, where we strive to compensate for the ugliness and discomfort of outside, by the enhanced cheerfulness and attractiveness of our homes. I believe that in consequence of this, we have reached a standard of domestic comfort which is unknown in any other country. At the same time, we lose by comparison in nearly every other respect. Any pride we may have in our surroundings rarely extends beyond our own four walls, or, if we possess them, our garden palings. We suffer our river to become an open sewer, our buildings to be defaced by soot, our streets to be disfigured by huge advertisement hoardings, and our atmosphere to be polluted by smoke.

If the pollution of the river and the air, and the existence of unwholesome courts and uninhabitable dwellings offended the æsthetic sense only, we might wisely leave their disappearance to the improving hand of Time. But we know, without the aid of mortality tables, that these things affect

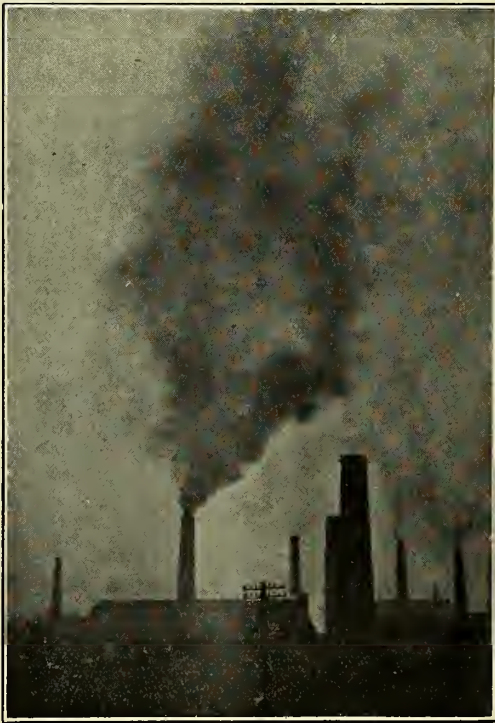
health, that they are therefore a source of danger to the community, and should not be permitted to exist longer than is needful for their removal.

And there is another weighty consideration, which should encourage us to take these matters in hand with as little delay as possible. We know from the Registrar-General's report, that three-quarters of the whole population of England and Wales has drifted into the towns. Over twenty millions of English people are dwellers in cities, and in those clusters of small daughter towns, which have grown up around them with all the harsh features, but with none of the elevating influences of the parent city.

If the conditions of life in towns are unhealthy, and if the air, the very fountain of health, is polluted, then we have to face this fact, that three-quarters of the whole population are living under these conditions, and that, in proportion as the rural population diminishes, the invigorating admixture of country labour will decrease. Mr. Acland stated in an address delivered a little time ago, that "all those who are making a careful study of the condition of our towns were perfectly aware of this fact, that a great deal of the work in the towns, which necessitated strong and healthy men, was done by those who had been brought up in country homes and not in towns." It is just worth while considering what might happen, if country homes should disappear or cease to feed the town with healthy labour.

PART I.

I WILL first refer to the subject of smoke. There is daily sent into the air of Leeds about 20 tons of soot, of which half-a-ton falls, and of that half-ton, 20 to 25 pounds sticks, *i.e.*, is not removable by rain.



A Leeds Boiler Chimney.

I have estimated that, in Leeds, 4,000 tons of coal on the average are consumed every working day of the year. I don't know what the ratio of house consumption is to factory consumption ; but the amount of soot given off from factory chimneys is, at the lowest estimate, $\frac{1}{2}$ to $\frac{3}{4}$ per cent. of the

coal. From house coal I have found, from a number of analyses, that the average is over five per cent. The domestic hearth is therefore an important factor in the smoke nuisance. How far we can hope to solve successfully the problem of preventing house smoke by the use of gas or coke, it is difficult to say. Mr. Russell and I have carefully studied the question of gas fires from this point of view, and our results are embodied in a small pamphlet, which members of this Society may obtain gratuitously from Mr. Jackson, bookseller, of Leeds. I am afraid that the present high price of gas will offer the main obstacle to its general use.*

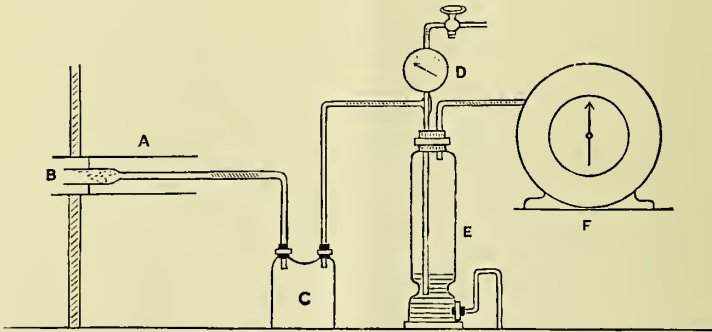
Supposing, then, that of the 4,000 tons of coal burnt daily in Leeds, one-half per cent. only escapes into the air as soot, this will represent 20 tons of soot a day.

Now I must ask you to follow me through a simple calculation. The thickly populated part of Leeds covers about four square miles, with the Parish Church as centre. We will call these four square miles the *smoke infected area*. That does not imply that the smoke does not extend beyond,† but it is most concentrated in that region. If there are 20 tons of soot delivered to the air in 12 hours, and if the air is renewed on the average 50 times in 12 hours, as there is reason to believe, then there is in the infected area, at any one moment, 8 cwt. of soot in suspension. Now, Angus Smith estimates that the smoke probably rises to a height of 300 feet on the average, before being dispersed. We can calculate on this assumption how much soot there is in 100 cubic feet. It works out to almost exactly 1·2 milligrammes. If then there are 20 tons of soot sent into the air in the day, and the other factors

* Anyone who has lived in the big towns of Germany or France must have remarked upon their freedom from soot. In these countries the big domestic stoves, in which wood, coke, or coal is burnt, are most effective as well as economical heating appliances. They consume very little fuel and emit practically no smoke. Moreover, they cause no cold draught along the floor, from which we, with our wasteful open fire-places, invariably suffer. The absence of ventilation in the rooms is the only drawback that can be reasonably urged against the continental system—a defect which might easily be remedied.

† Soot deposit is certainly perceptible at a distance of 9 miles from Leeds, and seeing that salt particles are often carried to Leeds from the Irish Sea, the more attenuated smoke particles will travel a still greater distance before falling.

are correct, there should be 1·2 milligrammes of soot at any moment in 100 cubic feet of Leeds air, on a working day. I made this calculation before I began my experiments, in order to ascertain approximately the quantity of soot I must prepare myself to deal with. The following is a diagram of the apparatus employed for estimating the solid matter in Leeds air.



A is a leaden tube fixed through one of the windows of the Philosophical Hall, about 18 feet above the ground, and overlooking a side street where there was practically no traffic. Through a cork diaphragm within this, is fixed an open glass tube, B, consisting of a wide portion in front, and a narrow tail piece. The wide portion contains a carefully weighed plug of cotton wool, which filters the air and collects the solid matter. This plug was always dried and weighed against a similar plug. The glass tube, B, is connected with an empty bottle, C, and a Desaga water-jet aspirator, D, which is fixed into a large wash tower, E, so that air can be aspirated through B and C, and delivered to the experimental gas meter F for measurement.

The apparatus was in work daily, except Sundays, from the middle of April to the middle of June, 1894, *i.e.*, 50 days, 20 cubic feet of air being aspirated daily. The average of two sets of experiments gave 1·2 and 1·16 milligrammes respectively in 100 cubic feet, which comes very close to the estimated quantity. It is needless to state, that at the end of one day, the exposed end of the plug was perfectly black, from the accumulation of particles of soot. I think, then, that we shall not be far from the mark in accepting the figure I have given, *viz.* : 20 tons a day, or 6,000 tons, value £300, a year, as the minimum loss of fuel in the form of soot.

This amount may appear too trifling to offer any inducement to alter the present system, but we must not infer from the value of fuel lost as soot, that more complete combustion would not effect a greater economy than represented by £300; indeed, it has been shown that a very material saving is effected by the abolition of smoke. We must also add to this loss account a heavy domestic washing bill. A lady who formerly resided in Leeds, and has now a precisely similar establishment in the country (*i.e.*, the same sized house and the same servants), has sent the following replies to a series of questions. She is a very careful housekeeper, and keeps strict accounts. She says that the quantity of soap used in cleaning a room is less than half of that used in Leeds, the labour of cleaning less than a quarter. Windows now require cleaning once a month; at least once a fortnight, and sometimes once a week, having been necessary in Leeds. White curtains now last eighteen months; in Leeds they were black in three weeks or a month. Generally speaking, white fabrics (toilet covers, counterpanes, etc.) last three times as long as formerly. The gilding of pictures remains free from discoloration, and silver plate and brass work keep wonderfully clean in the country; whereas two or three hours in Leeds, on some winter days, have been sufficient to spoil several hours' work of a parlourmaid. If three servants are required to do the work of a town house, two would do it easily in the country.*

And now I should like to explain how the quantity of soot that falls—it might be termed the daily soot-fall—is estimated. In January of 1892, when snow fell, and lay on the ground for several consecutive days, during clear and frosty weather, I determined the amount of solid matter in the snow lying in the Parish Church yard. A square yard of snow was removed daily from a fresh surface, *i.e.*, from a

* It would be of interest to compare the cost of washing of the poorer population in town and country. "The Budgets" published by the Economic Club give statistics of this kind. But the variable standard of cleanliness, and the nature of the trade in both town and country, render any reliable comparison impossible. It may be of interest to know that in four working-class families, of Ancoats, Manchester, with incomes varying from 16 to 38 shillings a week, the weekly outlay for soap comes to 1d. per head.

different gravestone, melted and analysed. The soot-fall amounted to about half-a-ton a day on the smoke-infected area of the city. Here is a photograph of the samples of melted snow.

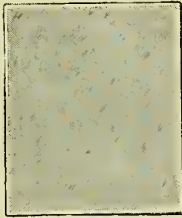


The four bottles shown in the photograph contain specimens of the melted snow in the order in which the samples were taken. The first was very dirty, but the last was absolutely opaque.

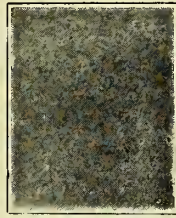
Soot is not pure carbon ; but it contains about 15 per cent. of a thick oil by virtue of which it adheres tenaciously to everything, so that much of it cannot be removed by rain. It is, in fact, a kind of varnish. In order to ascertain the effects of this sticky material in the soot, I stationed, during the winter and spring of '93 and '94, three glass plates, a foot square, one in a garden at Pool (9 miles from the centre of Leeds), one on the roof of the Yorkshire College (one-and-a-half miles from the centre of Leeds), and one on the roof of the Philosophical Hall (near the centre of the city). They were all removed from the immediate neighbourhood of chimneys. The deposit on these plates, after an exposure of a few weeks (loose matter having been washed away by rinsing the plates with water), was analysed and weighed. Fresh plates were then put in the places of those removed, and the process repeated from month to month.

The deposit consisted of 50 per cent. of carbon, or, roughly, three-quarters of it was soot, and the proportion was as follows :—**For one part deposited at Pool, there were ten times that quantity at the Yorkshire College,**

and twenty-four times the amount at the Philosophical Hall. The amount of deposit varied at different times of the year, but the above ratio remained practically constant. The following photograph shows the appearance of two plates after a year's exposure, one in the country and the other in town, and the difference is striking, the town plate being almost opaque, whereas the country plate appears nearly as clean as when first put out.



Country Plate.



Town Plate.

This black adhesive film represents a daily deposit weighing about 25 lbs., which covers the smoke-infected area with a permanent cloak of fast colour, which will stand washing. It is this adhesive deposit which discolours buildings and blackens vegetation. Unfortunately, it does more than blacken vegetation, it fills up the pores of the leaf and gradually destroys the plant. The photograph represents a holly leaf taken from the College grounds, from one-half of which the soot has been carefully removed, and the green colour has then been bleached, the soot remaining intact. Until we can abolish smoke there seems little prospect of inducing any



but the hardiest plants to flourish near the centre of our big towns.

The very birds of the air are tarred with this universal tar brush. I am indebted to Professor Ransome for a Leeds

magpie, shot near Stainbeck Lane, who bears evident signs of his town residence. Not only are the white feathers badly discoloured, but there is a striking absence of the gloss and beautiful iridescence of the black ones, visible in this country magpie.

Finally, I must mention another effect of smoke, and that is the amount of light absorbed by the smoke-cloud hanging over the city. We are not blessed with too much light at any time, especially during the winter months, and yet the smoke in some parts of the city absorbs about one-quarter of the total daylight. I have registered by a well-known method* the total daylight on a spot on Woodhouse Moor (a high open park lying to the north-west of the town), nearly every day during the past four months. Messrs. Wood and Bedford, of Kirkstall Road,† very kindly permitted their chemist to do the same, and to him I desire to acknowledge my indebtedness. A similar set of experiments have been carried out here on the roof of the Philosophical Hall.

LIGHT TESTS.

Being a comparison of the total daylight in different parts of Leeds.

Date—1895.	Woodhouse Moor.	Philosophical Hall.	Kirkstall Road.
July 1—7	... not recorded	... 78'30	... —
8—14	... „	... 88'30	... 83'60
15—21	... „	... 61'70	... 60'60
22—28	... „	... 65'30	... 58'50
Nov. 10—16	... 22'94	... not recorded	... 20'61
17—23	... 15'92	... „	... 12'25
24—30	... 10'20	... „	... 6'10
Dec. 1—7	... 10'90	... „	... 10'34
8—14	... 18'30	... „	... 7'17
15—21	... 4'50	... 4'80*	... 3'53
29— 4	... 2'60	... 1'99	... 1'53
Jan. 5—11	... 4'65	... 2'32	... 2'51
12—18	... 7'88	... 5'60	... 5'51
19—25	... 8'17	... 5'90	... 5'47
26— 1	... 13'66	... 9'02	... 8'04
Feb. 2— 8	... 6'56	... 7'20*	... 7'58*
9—15	... 8'28	... 9'05*	... 10'57*
16—22	... 3'82	... 4'40*	... 3'26

To economise space the results for each week are added together.

* The six numbers marked with an asterisk are exceptions to the general rule. For some unexplained reason, the amount of light registered on these dates is greater in the smokier parts of the town than on the open moor.

* The method used was to estimate the amount of iodine liberated on exposure from a mixture of potassium iodide and sulphuric acid. The numbers represent cubic centimeters of thiosulphate solution used.

† The position of these works would be a little to left of the centre of the view, shown in the frontispiece.

Before leaving the subject of smoke I desire, as a member of the Leeds Smoke Abatement Committee, in whose proceedings I have for some years taken an interest, to justify a recent resolution passed by that committee. The resolution is as follows:—"That the Smoke Abatement Societies of other towns be requested to co-operate in a memorial to the Local Government Board, praying them to have all chimneys connected with manufacturing industries included in the Alkali Act, so that they may come under the inspection of the Local Government Board, not under that of the Local Authority." At the annual meeting of the Sanitary Aid Society, the Deputy-Mayor (Mr. Gordon) objected to the resolution on the following grounds: The Local Authority, he said, could do more than the Local Government Board, whose system he regarded as too rigid. The smoke nuisance might be removed by an appeal to local patriotism, and by impressing upon manufacturers the fact that it would be more profitable to consume their smoke.

Anyone acquainted with the work of the Smoke Abatement Societies in Manchester, Leeds, Sheffield, Glasgow, and elsewhere, must know that such appeals have been made *ad nauseam*, without producing the slightest effect.

Some years ago the late Mr. Herbert Fletcher, of Bolton, a gentleman who identified himself with many movements for improving the condition of the working classes, tackled the problem of factory smoke. Himself a large colliery owner, he began with his own collieries, where he soon succeeded in abolishing every vestige of smoke. He tried to induce others to imitate him, but he was met by the reply that many appliances for smoke prevention in the market proved ineffective, and that it was impossible to be sure of obtaining a good article. Mr. Fletcher then became the active hon. secretary of a committee called the Committee for Testing Smoke-Preventing Appliances, the object of which was to test and report upon every accredited appliance which existed, or might be subsequently introduced for preventing smoke.

Manufacturers were invited to join, the subscription being the modest sum of ten shillings a boiler. A meeting was called in Leeds in 1890. It was very thinly attended, and not half-a-dozen subscriptions were raised. There have also been subsequent meetings held under the auspices of the Leeds Smoke Abatement Society, to discuss smoke-preventing appliances, and on such occasions manufacturers have been conspicuous by their absence. That is all that *local patriotism* has been able to do in Leeds. Mr. Fletcher, however, continued up to the time of his death to carry out the tests at considerable cost and trouble. These tests, along with those of other observers, are embodied in a report, which will shortly be published. They furnish, perhaps, the most complete and trustworthy record of practical smoke-preventing tests that have ever been compiled.* The report confirms the conclusions of all, who have carefully studied the subject of smoke prevention from boiler chimneys, and contains the following statement:—“**A manufacturing district might be free from manufacturing smoke, at least from the steam boilers.**”

That is also the published opinion of the Sheffield and Glasgow Smoke Abatement Societies, after careful experimental enquiry, and of the sub-committees of the Blackburn and Rochdale Corporations, both of which passed a resolution to that effect, after visiting a number of smokeless works.

Mr. Gordon stated that the Local Authority could do more than the Local Government Board. I do not contest the statement ; but that is not the present question. The question is, “Will it ever do more than it has done?” Whatever may be the cause, the present system has never been effective in Leeds, or for that matter in any other town, except perhaps Nottingham, because there *it is in the interest of the lace industry to suppress the smoke*, and smoke is practically abolished.

* Since this lecture was delivered, the Report of the Committee for Testing Smoke-Preventing Appliances (Guardian Printing Works, Manchester), has been published.

The offending resolution of the Leeds Smoke Abatement Committee has been imputed to their belief that the smoke inspector is under local influence, and that inspection is not impartial.

Let us examine what the law in Leeds is and how it is administered. In addition to the Public Health Act of 1875, which is capable of a rather elastic application, we have a local by-law which limits the emission of black smoke from boiler chimneys to a total duration of five minutes in the hour. This is pretty generous compared with some other towns, Manchester allowing one minute in the hour, Nottingham, five minutes in the morning of each day.*

Last year a report was drawn up by the Leeds Smoke Abatement Committee, containing hourly observations of 79 boiler chimneys. Two independent inspectors were appointed—both trustworthy men. The object in appointing two inspectors was to have independent testimony. As a matter of fact, the men had no object in exaggerating their report; moreover, they were instructed to observe only one chimney at a time, to keep as exact a record as possible, and, if in doubt as to whether the smoke were opaque or translucent, to give the benefit of the doubt to the chimney. The chimneys were boiler chimneys only, and they were selected at random in different parts of the town. And this was the result: Of 79 chimneys inspected, 51 emitted black opaque smoke for over ten minutes in the hour.

These observations, which lasted three weeks in all, gave evidence of 51 bad defaulters. Yet, if we turn to the annual report of the Medical Officer, we find that there are, on the average, *half-a-dozen convictions* for smoke nuisance in the year, and perhaps double that number of summonses.

* In Chemnitz, in Saxony, a manufacturing town with a population not very much smaller than that of Leeds, and its chief competitor abroad in the woollen trade, there is very little smoke. On inquiry there, it was found that not only are smoke-preventing appliances in general use, but in addition to annual prizes given to the stokers for good firing, some of the works offer a small reward to outsiders for informing the manager of the emission of smoke. It is not surprising to find a large ornamental park in the middle of the town, trees lining the main thoroughfares, and, in one factory visited, strawberries growing under the factory wall.

This report was sent to the Sanitary Committee of the Corporation, and the only answer they vouchsafed was practically to challenge the results by offering to let their inspector accompany a member of the Smoke Abatement Committee on another round of observations, a challenge which, it is needless to say, was not accepted. I do not wish to prolong this subject. Everyone who has considered the matter impartially has been convinced of the defects of the present system.

That is the conclusion of the Leeds and Manchester Smoke Abatement Societies. After appealing to the Local Authority and to the manufacturer for years, the Manchester Society is about to adopt the somewhat drastic expedient of persistent prosecutions of offenders as the only course left open to it.

In one of his annual reports, Mr. A. E. Fletcher, former chief Alkali Inspector, has said :—"The complaints that are brought against the emission of black smoke from factory chimneys are numerous, but too intermittent and desultory to bring about much diminution of the evil. The Alkali Act gives no power to control common coal smoke, yet at two points it comes so near it, that the question has often received my close attention. It is a curable evil, and therefore ought to be cured." The same authority has also said, "There are difficulties in making any change. Masters will not take the trouble to alter their furnaces, nor will the men alter their method of stoking the fires unless they are compelled. The numberless alterations, made in the construction and conduct of chemical works during the last twenty years, would never have been carried out, but for the pressure brought on the manufacturers by means of the Alkali Act. So it will be with the smoke nuisance."

The Leeds Smoke Abatement Committee has, I think, taken a wise course in adopting, in the above resolution, the suggestion of the former chief Alkali Inspector. Under the Alkali Act, inspection is thorough, but not inflexible. The

inspectors are among the very best trained chemists in the country, and chemical manufacturers readily acknowledge the value of their advice, and the undoubted benefit which has accrued through them to the industry.

I believe that properly trained scientific smoke inspectors, appointed through the Local Government Board, would be an equal boon to the manufacturer, who would soon be led to discover, as many have done already, that a material economy can be effected by abolishing smoke.

I trust that manufacturers will encourage this movement of the Smoke Abatement Societies, as one which, though undertaken in the public interest, will ultimately prove of direct advantage to themselves.



SHAW YARD — A LEEDS SLUM.

PART II.

AN account of the impurities in the air of a large town would be incomplete without some allusion to that busy and invisible population—the microbes—their numbers and their favourite haunts. The method, which I have used for collecting and counting them in different parts of Leeds, is that described by Professor Percy Frankland (*Phil. Trans.* 178, 257).

I have devised a slightly modified apparatus, so as to render it more portable.

In order to collect samples of air, and compare the numbers of microbes contained in them with those of open places, like Woodhouse Moor, several rounds of visits have been made to different parts of Leeds, including the courts and yards in “the insanitary area.” The experiments, as far as they have been carried, agree with what might have been anticipated. The enclosed and dirty courts are more thickly inhabited by these organisms than the more open and cleaner places.

Samples taken on Woodhouse Moor, and on the tennis court of the Yorkshire College, in January and February of the present year, gave on the average 11 bacteria in 1 cubic foot of air, whilst the samples drawn from the slums, on the same days, contained on the average six times this number.* These experiments are still in progress.

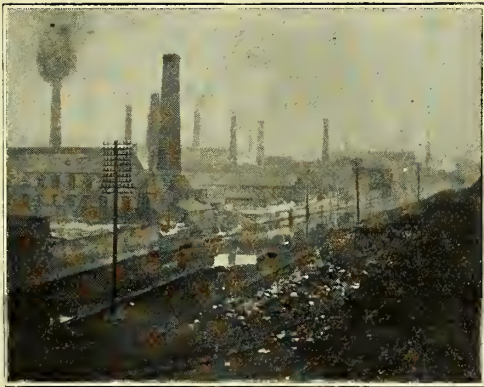
It does not follow that these microbes are injurious, but there is no doubt that where they find a fruitful soil for growth, in such places we may expect disease germs to flourish.

Considering what an energetic and progressive community we are, I think we exhibit an unusual amount of deliberation in dealing with the delicate problem of the removal of these

* Experiments carried out in July of this year gave a much higher number for the slums, thirteen samples containing an average of 140 bacteria in 1 cubic foot.

slums, which, it cannot be too often repeated, are a disgrace to our modern civilization. Our insanitary areas might be districts under the Sultan's sway, or at least under the protection of a European Concert, so tardy are we in introducing much needed reforms. But it would be unfair to say more on this subject at the present time, for I understand that very shortly the Local Government Board Commissioner will be here to take evidence on a great scheme of sanitary reform, now before the Sanitary Committee of the Corporation.† I am sure that every one, who has the interest of the poorer class of our community and the credit of the City of Leeds at heart, must wish the Sanitary Committee success in carrying it through. Ladies and gentlemen, I have little more to add. One is sometimes led to contemplate the causes which render the removal of some abuses so very difficult. I used to think that the turtle, the presiding genius of the aldermanic feast, had an allegorical significance—an animal active within the sphere of its own body; but generally incapable of very rapid progress. We must not forget that if changes come about very slowly, it is because, in the words of Mr. A. E. Fletcher, "Pressure is needed from outside; a determination on the part of the public that the evil shall cease."

† This scheme has since been passed.



The River Aire, Leeds.

Dank and foul, dank and foul,
Through the smoky town with its murky cowl ;
Foul and dank, foul and dank,
By sewer and wharf, and slimy bank.

Kingsley.

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